Industrial Waste Diversion Program

Final Reports #9

EVALUATION AND RESEARCH REPORT ON THE USE OF A NEW BIODEGRADABLE RESIN

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INDUSTRIAL WASTE DIVERSION PROGRAM
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Evaluation And Research Report On The Use Of A New Biodegradable Resin

Report prepared for :

Waste Management Branch
Ontario Ministry of the Environment

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Report prepared for:

Waste Management Branch
Ontario Ministry of the Environment

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DISCLAIMER

This report is in partial fulfillment of conditions of a grant given to Uthane Research Ltd. by the Ministry of the Environment under the Industrial Waste Diversion Program. The report was prepared by Suzanne Irwin-Whylie for Uthane Research Ltd. and documents results of work for which the Ministry of the Environment provided financial assistance.

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INTRODUCTION

This study has been undertaken for Uthane Research Ltd., to identify potential markets, determine existing competition and prices in order to lend insight into the intended use of a new biodegradable resin which has been developed by Uthane Research Ltd., for proposed use in a variety of applications.

The initial research efforts concluded that the topic of waste management being such a controversial issue required a more detailed overview in dealing with the many different groups having diverging opinions on what constitutes important criteria for a "biodegradable" product. This report has been written so as to ensure that the proposed product applications of Uthane Research Ltd., are compatible with opportunities for waste reduction, reuse, recycling and recovery.

BACKGROUND INFORMATION

Present Waste Situation

What to do with our garbage? This simple statement has become one of the most talked about and controversial issues of today. Canada, the United States and many parts of the world are faced with crisis situations of solid waste disposal.

Canada itself is comprised of 10 million square kilometres and supports a population of 25 million people. Most of this population lives within 160 kilometres of the American border in a strip that stretches across six time zones from the Atlantic to the Pacific. The average Canadian generates one tonne of garbage per capita per year which equates to 25 million tonnes per year of residential garbage in Canada.[1] Residential contributes one third of the garbage while it is believed that industry and business is responsible for the remaining two thirds of the garbage. Until recently, there has been little or no regard to what has been thrown away nor in what quantities. Waste management is clearly emerging as the major challenge facing the municipal government in Canada.

Because of today's urban lifestyles, both men and women are out in the workforce. In order to support this lifestyle both speed and convenience have become essential, resulting in a "throw away" society. Unfortunately, the volumes of waste are mounting out of proportion to the space available to place all of the refuse. Canadian cities in the past have relied on landfill sites to dispose of 90% of the waste generated.[2] The critical situation of the landfill sites in Canadian towns and cities is evident by the following survey results. In Vancouver a great percentage of waste is already transported over 200 kilometres away to Cache Creek. In Edmonton the landfill site which receives 75% of the garbage will be full by 1990 and in Regina the only landfill site will last until 1990. In Windsor and the county of Essex the three landfill sites are already nearly at capacity. By 1993 Montreal will lose 90% of its waste disposal capacity, while the only landfill site in Halifax will be exhausted in 1994.[3]

Waste disposal affects all the major urban centres in Canada, but it is most severe in Toronto. Metro Toronto and its surrounding municipalities of Durham, Halton, Peel and York generate 3.7 million tonnes of garbage per year.[4] Today Toronto has two existing landfill sites: one in Durham Region, the Brock West Landfill in the Town of Pickering and the other in York Region, the Keele Valley Landfill in the Town of Vaughan. Presently two thirds of Metro's existing garbage is sent to Keele Valley while the remaining one third is sent to Brock West.[5] By 1990 Toronto will lose 33% of its disposal capacity with the closure of Brock West. Keele Valley is expected to follow suit and be at full capacity by 1993.[6] This leaves less than five years to not only address this critical situation, but also to collect detailed data, formulate specific plans and enact those plans.

What is in the Municipal Waste Stream?

As a result of the conglomerate of mixed garbage taken to the landfill sites, there tends to be discrepancies in the data available. As well, most of the information dates back ten years. The Ministry of Environment has drafted proposals to undertake a Canadian composition study, however, because of the nature and scope of the project, it is not expected to receive approval before April 1989 and the estimated completion date is fifteen months from date of approval.[7]

There is little information available on the actual composition of commercial and industrial waste. For the purposes of this report the most up to date data relating to the composition of solid waste has been obtained from information compiled in 1988 by the Ministry of Environment.

Composition of Ontario Municipal Solid Waste
(Residential and Commercial/Industrial)

	Percentage (%) by weight	Metric Tonnes
Food Wastes	22%	2,200,000
Other Paper	20.6%	2,060,000
Newspaper	14.4%	1,440,000
Yard Wastes	15%	1,500,000
Plastic/Rubber Leather	5%	500,000
Wood	3%	300,000
Cloth & Miscellaneous	4%	400,000
Glass	5%	500,000
Cars	5.2%	520,000
Ferrous Metal	0.5%	50,000
Non-Ferrous Metal	0.7%	70,000
Miscellaneous	4.6%	460,000
	100%	10,000,000 [8]

The Ministry of Environment staff estimate that 10,000,000 tonnes of municipal solid waste from residential and commercial/industrial sources was disposed of in 1988.

Cited as today's major waste problems are cardboard, newspapers, bottles, cans and tires.[9] Newspapers, constituting up to 10% of landfills, are still intact after 10 years of landfill burial.[10]

Although the plastic industry has been the target of much discussion and pressure, plastics, in fact, account for only 5 - 7.2% (depending on the source) of the total waste stream.[11] However, there continues to be great debate about the future and long term objectives of the plastics industry because of the high visibility which plastics play in our lives. This whole issue will be addressed further along in the report under the heading of biodegradables.

WASTE MANAGEMENT ALTERNATIVES

As previously discussed, our existing landfill sites in Canada are quickly coming to the end of their life cycles. Specifically in Toronto with the impending closure of Keele Valley in 1993. What are the waste management alternatives?

1. To locate new landfill sites.

2. Four R's - Reduction
   Re-Use
   Recycling
   Materials Recovery

3. Composting

4. Refuse derived fuel

5. Incineration - with energy recovery
   - without energy recovery

6. Exporting

1. New Landfill Sites

There are a number of drawbacks associated with new sites.

a) Large tracts of land are required. In the past these have been located close to urban centres in order to keep transportation costs down. As the public awareness increases, the opposition to having "garbage dumps" in people's backyards has grown fiercely.

b) Landfill sites require constant care and monitoring to prevent the potential hazard of the leaking of leachates into local water supplies.

The municipalites in Ontario are actively seeking out new landfill sites, however, as yet nothing has been approved.

2. The Four R's

The Four R's of solid waste management are recognized worldwide.

Reduction — Keeping materials out of the waste stream by changing packaging, substituting reusable items in place of disposable ones and developing products that are more durable.

Reuse — Involves the direct reuse of materials which have already served their primary purpose. For example: soft drink bottles being kept and used to store other liquids or reusing empty margarine containers for food or other items for storage.

Recycling — The collection of specific waste materials for use in the manufacture of new products.

There are presently two companies in Ontario which are involved with recycling: Consolidated Fibres, a private company in Toronto with its own recycling plant and Durham Recycling Centre which is a non-profit organization in Whitby.

The most common materials collected through municipal recycling programs include newspapers, glass, tin, food containers and aluminum beverage containers. Drywall, wood, tires and clear non-waxed corrugated are all proposed recyclable items. Each tonne of waste paper separated from municipal solid waste for recycling saves over three cubic yards of landfill space.[12] The present price for newspaper for recycling purposes is $60 per metric tonne.[13] Presently the two largest sources of wastepaper collection for recycling are corrugated boxes and old newspapers.[14] It is believed that recycling could potentially reduce the waste stream by 10 - 30%.[15]

Recovery The separation and retrieval of usable materials and/or production of energy from mixed solid waste after it is collected. The most commonly recovered materials include: ferrous metals, aluminum, plastics, newspaper and corrugated cardboard and glass.

3. Composting

Composting is a process that converts organic waste into a material that can be used as a soil conditioner and low strength fertilizer. Composting would make use of residential kitchen and yard waste as well as commercial wastes from restaurants. Sewage sludge from sewage treatment plants can also be composted. It is estimated that in some areas as much as 35% of residential waste could be composted.

4. Refuse Derived Fuel

Refuse derived fuel is the production of a usable fuel from mixed solid waste which has been separated. This fuel is then used at waste incinerators or sold to industries as a supplementary fuel. The problem with refuse derived fuel is that its production requires high capital and operating costs. There is also the problem of disposing of residues and ash after the fuel is burned.

5. Incineration

There is little debate that if incineration is going to occur then incineration with energy recovery makes the most sense. There is, however, much debate on whether or not incineration should be a part of waste management. Municipal energy from waste is common in the U.S.A., Europe and Japan ranging from 35 - 70% of waste burned in incinerators.[16] Canada has only burned as much as 4% and in August 1988 the only operating municipal incinerator in Metropolitan Toronto (Commissioner's Street Incinerator) was closed.[17] Incineration, on one hand, is very appealing as it can decrease

the volume of waste to be landfilled by as much as 90 - 95%.[18] Unfortunately, garbage incineration has been reported to be the largest single source of dioxins into the Canadian environment. The present state-of-the-art incinerators have technology which consists of a lime scrubber and a bag house of fabric filters. This equipment produces flyash and residues with high concentrations of heavy metals and dioxins scavenged from flue gas. Although the scrubbers within the air pollution control systems may reduce emission of the contaminants into the air, there is still a disposal problem of highly toxic residue which has been produced. The question now is where to dispose of the toxic ash. There are presently proposals to retrofit and build in and around Toronto sixteen incineration plants. If built, these plants would be capable of incinerating an estimated 5,000 tonnes of garbage per day.[19] On the negative side, this also means an additional load of up to 15 kg of dioxins and furans each year.[20]

6. Exporting

Exporting means shipping wastes to new and/or existing solid waste management facilities outside of the jurisdiction of the area in which waste is generated. This, however, would generate higher haulage and tipping costs. There are municipalities in Canada which already export their wastes.

As we have discussed, there are a number of options available for waste management. Each alternative has its own advantages and disadvantages, but clearly no single option solves the total waste disposal problem.

Private and public sectors, industrial/commercial and environmentalists groups strongly advocate the reduction of wastes as the number one goal to meet not only the immediate waste crisis, but also to include reduction in all short and long term plans for waste management. Also strongly advocated by most groups is recycling whenever feasible.

Ontario presently gives priority to measures that will reduce the amount of material in the waste stream and second priority to the reuse/recycling of materials versus burning or burying materials.

The provincial government advocates that municipal dependency on landfilling be reduced and that reduction, reuse, recycling and recovery play significent roles on all solid waste management mixes.

The Ministry of Energy has put up $25 million over five years to support Energy From Waste (E.F.W.) projects in Ontario.[21]

As alluded to earlier in this report, during the many discussions and media coverage as a result of the garbage crisis, the plastics industry has become a prime target for criticism. This leads us to the attitudes and response of industry to the whole issue of waste disposal.

ATTITUDES OF COMMERCIAL/INDUSTRIAL SECTORS

In Canada, it is believed that two thirds of the total municipal waste stream is from the commercial/industrial sectors and from this belief alone the commercial sectors have had to address the problems.[22] The business sectors in many cases have substantial dollars to lose should their markets be changed or interfered with because of government legislation or rulings. One of the main issues which has surfaced affecting many businesses is the very controversial subject of biodegradability. The subject alone has brought forth many opposing views and has made a number of industries do some in-depth research into the biodegradable question to ensure their markets can be protected, but at the same time meet necessary acceptable criteria required for future waste disposal methods as well as satisfy consumer and environmental demands.

The Medical Industry

At this time there is no organized force for change. There is tremendous concern in the U.S.A. as they are already moving to implement legislation to ban disposable infant and adult diapers because of the non-degradable polyethylene backing. This is hitting a market of over 10 billion diapers and in excess of $640 million to U.S. industries. In Canada, although a great deal of time is being invested into biodegradability by the medical industry and the polyethylene manufacturers, there is not a unanimous feeling that the answer is a biodegradable plastic. The industry must also deal with the non-woven cover stock and the opaque packaging, neither of which is biodegradable. Many are of the mind that, in fact,incineration may be the answer.[23]

The medical industry has also noted that the acute care/long term care and chronic care facilities that purchase adult incontinent diapers for the end-user are reassessing the issue of reusable (cloth) versus disposable diapers because of the waste problem and increased tipping fees for waste removal by the waste management companies.[24] An example of drastic

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increases implemented by Metro Toronto indicates the seriousness of forcing business and industry to reduce garbage. Metro Toronto tipping fees:

1987 = $18/tonne
1988 = $50/tonne
1989 = $85/tonne.[25]

The medical industry in Canada has at stake over 250 million adult and infant diapers and a market worth over $100 million.[26] Infant diapers alone generate 57,000 tonnes into the Canadian municipal waste stream.[27]

Plastic Industry

The entire industry is fully aware of the burden placed upon it to support and offer solutions that contribute to helping solve the problems of solid waste disposal in Canada.

Plastic is continually singled out as a major problem but, depending on the study, all plastic products actually contribute between 5 - 7.2% to the waste stream.

Virtually the entire plastics industry, from the resin manufacturers to the manufacturers of the end products, are investigating the feasibility of biodegradable plastic and researching for acceptable resins. The plastics industry today is wrestling with the question of biodegradable - YES or NO. Is it the answer?

BIODEGRADABLE - IS IT THE ANSWER?

Thermoplastics, single-chain polymers, soften when heated and can be reheated and reshaped several times. It's the thermoplastics that account for approximately 80% of all the plastics produced.[28] The most widely used thermoplastics are as follows:

Low Density Polyethylene (LDPE)	64%
High Density Polyethylene (HDPE)	64%
Polystyrene (PS)	11%
Polypropylene (PP)	9%
Polyvinyl Chloride (PVC)	5%
Polyethylene Terephthalate (PET)	7% [29]

There are two ways in which plastics can be made to deteriorate. One method is through photodegradation where plastics require exposure to ultraviolet light for the breakdown process to occur. A second process is through biodegradation where it takes the action of microorganisms to degrade.

What is presently available on the market to meet the needs of the biodegradable issue? There are a number of companies which have produced photodegradable/biodegradable additive systems which are currently available. The biodegradable systems available for plastic presently involve either modified starch polymers or certain aliphatic polyester and copolyesters. The modified starch technology uses either silane treated starch for improved compatibility with polymers or starch modified with an ethylene/acrylic acid copolymer compatilizer. St. Lawrence Starch and Agri-Tech Industries, Gibson City, Illinois currently market modified starch polymers.

A photodegradable resin is produced by Union Carbide, Dow Chemical and Dupont as well as Ecoplastics Ltd., Ampacet Corporation and Ideamasters Inc. Princeton Polymer Lab offers a patented photodegradable technology for license to manufacturers, but does not produce its own resin.

Ampacet Corporation

Ampacet Corporation in Mt. Vernon, New York, has produced a photodegradable additive system for polyethylene called Poly-Grade for over fifteen years. The degradation process in Poly-Grade is a "photo-initiated oxidation system". Degradation begins as a result of ultraviolet light but may continue in the absence of light as the intermediate products undergo thermal decomposition. The company claims that products made with Poly-Grade will begin to degrade after thirty days and are completely degraded after ninety days. It must be noted, however, that seasonal and geographic variations make it difficult to predict product performance.

Ecoplastics Limited of Toronto

A subsiduary of ECO Corporation in Toronto, Ontario, this company has developed a technology which imparts photodegradability by altering the molecular structure of plastics with ketone-carbonyl groups. The product Ecolyte is a polymer resin which, when mixed with the polyethylene resin used in the manufacture of bags, renders the bags degradable. Ecolyte polymers contain a very small number of special chemical groups that are light sensitive. When an Ecolyte polymer is exposed to ultra-violet light, the light sensitive group absorbs the light and starts a sequence of chemical reactions. Plastics containing Ecolyte that are photodegradable become biodegradable and ultimately disappear. According to the company, the only biproducts are water and carbon dioxide.

The company received its first order in September 1987 from Safeway Canada Ltd. in Vancouver of approximately $45,000 for Ecolyte photobiodegradable bags. This was their first commercial use of Ecolyte bags in North America.

Also in 1987, Ecoplastics signed its first license with Sunbags International Ltd. of Vancouver and received its first photobiodegradable Ecolyte Masterbatch polyethylene. This is a concentrated plastic that, when mixed with regular polyethylene, will produce photobiodegradable

polyethylene finished goods. The licensing agreement provides for a 20% royalty fee on all sales of Ecolyte Masterbatch. Ecolyte continues to be sold in western Canada and Italy for degradable grocery bags.

In February 1988, it was announced that Eco Corporation of Toronto, through its U.S. subsiduary Eco Corporation U.S.A., and the Plastics Division of Polysar Inc. of Leominster, Massachusetts, have formed a joint venture to develop worldwide markets for a broad range of degradable plastics using Ecolyte technology. The joint venture, Ecosar Enterprises, will be headquartered at Polysar's Plastics Division in Leominster. Initial plans are to produce and sell Ecolyte degradable polystyrene to be used for fast food containers such as beverage cups and hamburger containers.

Ideamasters Inc.

Ideamasters Inc. in Miami, Florida has developed a photodegradable resin called Plasti-gone which also degrades through a photo-initiated oxidation system. Plastic containing this resin will begin to degrade in sunlight and continue to degrade in the dark and when buried in the soil. The product was originally developed in Israel in response to a requirement for biodegradable mulch film. Ideamasters is waiting for approval from F.D.A. within the next two years for the use of Plasti-gone in food packaging and skin contact products such as diapers.

ICI Americas

ICI Americas has developed a polyester copolymer that is itself susceptible to the enzyme action of microorganisms. For decades, scientists have known that certain soil bacteria produce a natural thermoplastic when fermented on sugars. Because the principle raw material is carbohydrates, not hydrocarbons, ICI began research on extracting and purifying this natural polyester. Using a naturally occurring bacteria called Alcaligenes eutrophus, ICI has come up with a biodegradable plastic called poly (3-hydroxybutyrate - 3 hydroxyvalerate) or PHBV. According to the company

PHBV plastic is totally natural, completely biodegradable and can be processed using conventional technology. PHBV is currently being used in surgical applications, but has potential for packaging and personal hygiene applications.

The present price/lb. is $15 but this is expected to drop to $1/lb. once a full scale plant operation is completed. This is planned through Marlborough Biopolymers Ltd. in England, a subsidiary of ICI Americas.

St. Lawrence Starch

St. Lawrence Starch, Mississauga, Ontario has available Ecostar Masterbatch which uses starch and an unsaturated ester such as corn oil. When an Ecostar product is buried the starch is attacked by microbes which leave a porous structure. The corn oil then reacts with the metal salts in the earth to create peroxides that further break down the polymer molecules.

Physical Properties of Ecostar

Description - Natural polymer, free flowing white powder
Granule Size - 15 microns for maize starch
5 microns for rice starch
80 microns for potato starch
Density (gm/cm^3) - 1.28
Thermal Stability - Stable to 230°C
Moisture Content - Less than 1% 30

The company claims that an Ecostar bag made with 6% starch would degrade completely within three to six years and that products containing Ecostar are normal in storage and break down only after disposal. At present, most Ecostar material has been exported to Italy, where legislation has been passed requiring that all carry-out shopping bags, garbage bags, and other packaging material be degradable or recyclable by 1991.

Guardian Poly Industries in Laval, Quebec is currently using the starch additive to produce and market a biodegradable garbage bag called "Bioguard". There has been no commercial application as yet in the U.S.A. St. Lawrence is waiting for sanction from the Canadian Department of Health and Welfare and the U.S. F.D.A. to use Ecostar in food packaging.

U.S. Department of Agriculture/Agri-Tech Industries

Agri-Tech Industries of Gibson City, Illinois has licensed a technology which combines corn starch with poly (ethylene-co-acrylic acid) or E.A.A. (a synthetic nondegradable polymer). The company plans to make garbage can liners. Although no commercial scale production has begun, Agri-Tech is planning a pilot plant aided by a $250,000 grant from the Illinois Corn Marketing Board.

SUMMARY OF AVAILABLE TECHNOLOGIES FOR DEGRADABLE PLASTICS

Source	Product Info	Degradation Type	Current/Potential Use
Dow Chemical Midland, MI DuPont Wilmington, DE Union Carbide Danbury, CT	E/CO resin	Photodegradable ethylene/carbon monoxide	Currently used in 13 states with 6-pack laws. Dow and DuPont have applied for FDA approval for food contact.
Ampacet Mt. Vernon, NY	Poly-Grade Masterbatch	Photodegradable additive system	Used in Good Sense bags, and mulch film.
Ecoplastics, Willowdale, Ont.	Ecolyte Masterbatch	Photodegradable ketone polymer	Used in mulch film grocery bags in Italy, Canada, and limited areas of U.S. Also used for PS and potentially PET.
Ideamasters, Miami, FL	Plasti-gone proprietary resin	Photodegradable additive system	Used in Israel and U.S. for mulch film. Wider use expected.
Princeton Polymer Labs Princeton, NJ	Additive system for licensing	Photodegradable additive system	No current commercial use. Suited for use in Polyolefins and PS.
ICI Americas, Wilmington, DE	PHBV resin	Biodegradable polyester copolymer	Production of bottle in Europe planned for late 1987.
St. Lawrence Starch, Mississauga, Ontario	Ecostar masterbatch	Biodegradable starch additive	Used in trash bags and bottles. No current U.S. use.
U.S. Dept. of Agriculture/ Agri-Tech	Technology available for licensing	Biodegradable starch additive	Agri-Tech Industries, Gibson City, IL plans pilot plant for film.

Source: Wrapped in Plastics, The Environmental Case for Reducing Plastics Packaging, Jeanne Wirta, August 1988.

PLASTICS ISSUE

Half of the waste we dispose of is packaging. Good data in Canada is unavailable, however, U.S. and Canadian consumer markets are felt to be similar so whenever feasible U.S. data will be used. Over 50 million tonnes of packaging material is produced annually in U.S.A. More than 35% of residential garbage is packaging materials.[31]

The Federation of Canadian Municipalities has requested that the Federal government study the reduction of packaging. Plastics stand to lose many of their markets to competing materials such as paper, glass and metal unless some mechanism is available for plastics to be recycled or degraded.

The plastics industry in the U.S. estimates consumption of plastic resins will grow from 48 billion pounds per year in 1985 to 76 billion pounds by the year 2000. This represents a 36% increase.[32]

Environment Canada has begun to advocate the use of degradable plastics.

The Society of Plastics Industry (SPI) is prepared to participate in a joint study with the Ministry of the Environment to determine:

- the effective degradability of <u>each</u> degradable plastic product;
- by products of degradation;
- standards for photo- and biodegradable products;
- a list of suggested products that may be suitable applications for photo- and biodegradable plastics but for which recycling may not be feasible.

In spite of the reluctance of the plastics industry, degradable plastics are being legislated into existence in both Western Europe and North America.

In Italy, by 1991, all plastics used in nondurable goods are to be degradable.[33] In the U.S. to date 12 states have barred or proposed bans on nondegradable plastic products ranging from egg cartons, tampon applicators and diapers. On the federal level, ten degradable plastic bills and a concurrent resolution are pending before congress.

SAMPLE OF PROPOSED BANS AND RESTRICTIONS ON PLASTICS

Year	State/Bill	Description
1981	Alaska	Bans non-degradable six-pack carriers.
1987	Berkely, CA City ordinance	Passed. Bans sale of CFC-blown polystyrene containers.
1988	Connecticut S 5885	Passed. Prohibits the distribution and sale of the plastic can in the state.
1987	New Jersey S 1542	Would ban non-degradable feminine hygiene products (tampons).
1988	New York City Ordinance 932	Would prohibit restaurants from using disposable service items for on-site.
1985	Oregon 2804	Would ban sale of non-biodegradable disposable diapers.
1985	Oregon AB 803	Would prohibit grocery stores from using or providing plastic bags.
1988	Suffolk County New York IR 1869-87	Passed. Bans sale of certain non-degradable food packaging, plastic grocery bags, certain PVC and PS packaging and utensils.
1987	Vermont H 196	Early version of bill would have banned the use of PVC as a packaging material.
1987	West Virginia	Would tax restaurants 5% of the wholesale value of non-biodegradable and non-recyclable plastics used.

Source: Solid Waste Legislative Data Base.

Ontario does not have formal policies related to degradable plastics. In June 1988, a resolution was introduced and passed in the legislature encouraging the Minister of the Environment to develop a plastics waste management policy as soon as possible. Resolution #34 received support from all parties but no time table was set forth.

Studies conducted by the Center for Environmental Management at Tufts University found that the life of a landfill can be extended by increasing the rate at which waste decomposes.[34]

ACCEPTABILITY OF EXISTING TECHNOLOGIES AND THEIR END PRODUCTS

There is a feeling that existing "biodegradables" available on the market are not doing what they are supposed to do. Existing biodegradables are poly/starch and an oxidizing agent. In an aerobic environment the starch will break down, however, in a landfill situation we are not dealing with aerobic conditions, but rather anaerobic. The anaerobic environment neutralizes the oxidizing agent and the starch is leached out.

The photodegradable product is designed to deal with litter problems, but what you end up with is small pieces of plastic. These small pieces are not perceived to be of any advantage over the original product.

If P.V.C., "acrylic" plastics were to become biodegradable, there would be much concern over the possibility of toxic substances being released.[35]

The techniques demonstrated to date rendering plastics biodegradable through the use of additives has very little support data on the actual process of biodisintegration.

First Brands (Canada) Corporation, the makers of Glad Products, has developed their own guidelines on which to base a degradable plastic. The following three statements outline their criteria:

1) A technology that will maintain functionality and performance standards.

2) A technology that supports the second-use or recycling of plastic, contributing to the ultimate goal of reduction in the waste stream.

3) A technology that will degrade plastic in the uncontrolled conditions of the waste disposal process and effectively extend landfill life without creating other environmental problems.

The cornstarch technology in its current form has been evaluated on the above three criteria and was found not to meet any one of the criteria. Although claims have been made that the products of starch biodegradation would be carbon dioxide and water, there is little published data to support this.[36]

Specific users of degradable plastic bags include Natures Choice, Bio Guard, Safeway, the Body Shop and the LCBO.

Limitations of Photodegradation

The use of photodegradable plastics is restricted to applications where the product will be exposed to adequate sunlight to promote decay process.

Limitations of Biodegradation

Biodegradation is not a fast process and is dependent on many external factors to complete the process including the composition, moisture and temperature of the soil.

A packaging material which is capable of supporting the growth of bacteria must be handled cautiously if used in packaging of foods having long shelf lives. Improper storage could lead to food contamination.

Attitudes Towards Degradation

Degradation has not been proven technically or economically. From the National Research Council, the opinion is that it is fortunate that commodity plastics are not biodegradable because this ensures that no products of microbial degradation can ever arise to contaminate water supplies, lead to landfill site instability or generate explosive gases.[37]

Biodegradation in landfill yields methane gas which is explosive and flammable. Packed tightly in landfill where little air penetrates the anerobic decomposition process takes over. Leachates must be contained or ground water pollution can occur.

It is felt that many plastic manufacturers are anxious for the opportunity to stamp the word degradable on their products to capitalize on public interest as well as relieve pressure on plastics packaging materials. This interim step also buys them time before other options such as recycling and waste to energy programs can be implemented.

Very little testing of degradable plastics has been done to support the development of standards and to resolve basic technical questions about the rate of degradation and the safety of the end products.

While it is desirable to induce degradability after the product is discarded, it is unlikely that any mechanism other than incineration will be efficient.

For each polymer a unique degradation chemistry will probably have to be developed.

Will plastic dust or small articles be acceptable?

The practical solution to the plastic solid-waste solution is to use degradable plastic materials. It is not practical to recycle plastic films and containers because there is no way that the recycled scrap can be separated into different types of plastic resins.

Environmental groups and individual researchers have raised serious questions about the actual benefits of degradable plastics and their possible adverse impacts upon the environment and recycling programs. On the other hand, degradable plastics are being promoted by some environmental groups because of their volume reduction attributes in municipal landfills and for litter reduction.

Primary concerns of degradable plastics are:

- harmful effects upon the environment;
- an increased potential for littering;
- adverse effects on plastics recycling programs;
- increased costs;
- lack of direction regarding the best uses.

POTENTIAL MARKETS FOR DEGRADABLE POLYMERS

Commodity Plastics such as
- grocery bags
- garbage bags
- agricultural mulch film*
- fast food packaging
- plastic food wrap
- time-release fertilizers*
- bags for use in municipal collection programs for composting organic waste*
- disposable diapers
- surgical sutures
- six pack loop carriers for beverage containers

* Potential markets which yield the least amount of opposition at this time.

There is a great deal of controversy surrounding the potential markets for "degradable" plastics.

Potential "Biodegradable" Markets

Garbage Bags

Canada - LDPE	49,876,376 kg.
Ontario - LDPE	26,688,290 kg.

These figures are available from Statistics Canada Survey Catalogue #47-007, 1987, and represent the total amount of garbage bags by weight.

In discussions with the Society of Plastics Industry Canada, data relating to units and dollar values are not available.

Shopping Bags

Canada -	LDPE	36,559,147 kg.
	HDPE	8,464,671 kg.
Ontario -	LDPE	15,698,198 kg.
	HDPE	3,974,513 kg.

Data obtained from Statistics Canada Survey Catalogue #47-007, 1987 and represent the total amount of shopping bags by weight.

The Society of Plastics Industry Canada actual units and dollar values are unavailable.

Agricultural Mulch Film

This is polyethylene film used by farmers during the planting season.

Present photodegradable mulch films save the farmer the time of having to remove the covering at the end of the planting season.

Estimated usage is 10 million lbs. annually in Canada.

In the U.S.A., agricultural mulch films consume 100 million pounds per year of polyethylene. The products must be tailored to different climates and soil conditions.

Although there is little opposition to biodegradable mulch films, concern has been expressed about the effects of fine particles of degraded material building up in the soil.

Plastic Flower Pots

Canada: 1984 - 21,800,372 dozen = 2.6 billion units
1985 - 27,022,865 dozen = 3.2 billion units

Source: Statistics Canada.

In discussions with Allan Conant, Marketing Manager for Kord Products Ltd. (largest pot manufacturer in North America), he felt these figures were very high. He stated that at this time there is no sophisticated data available regarding plastic pots and estimated the sales of flower pots to the growers to be approximately $30 million in Canada and $15-20 million in Ontario.

In terms of units, he felt one billion units would be a more accurate figure. The present cost to growers is $175/1000 units.

This is a company that would be most interested in pursuing "biodegradable" flower pots.

Disposable Diapers

Disposable diapers are composed of nonwoven polypropylene, cellulose pulp and a polyethylene backing.

Adult Institutional Market - the total market is worth $64 million in Canada for both cloth and disposable diapers. The disposable diaper market enjoys 82% of the total market which equates to 150 million pads per year and $57 1/2 million annually.38

Infant Diapers - The unit and dollar market has been confidential, however, the following information has enabled a unit value to be estimated for Metropolitan Toronto.

There are 53,000 children between the ages of 0-3 years old. 15% of these use cloth diapers equalling 7,950 children. 85% use disposable diapers

which equates to 45,050 children. It is estimated that, on average, each child utilizes 45 diapers per week which translates to 2.03 million diapers per week or 106 million diapers annually.[39]

Worldwide adult and infant disposable diapers have been estimated at 27 billion, while in the Canada and U.S., figures have been published at 11 billion diapers.

Half mil polyethylene used in the diaper costs an average of $1.20 per pound. With the starch additive the price is increased by 10-15% which appears to be acceptable at $1.32 - 1.38 per pound.[40]

Feminine Hygiene

Plastic applictors in tampons.

In discussions with Cheryl Hopkins, product Manager for Playtex, they are unable to give out statistical information regarding the number of sticks or the dollar market. She did, however, express a keen interest in a "biodegradable" plastic as opposed to a photodegradable. U.S. data indicates that in 1987 250 million pounds of HDPE was used for feminine hygiene insertion devices.

It has proven to be difficult to obtain certain market information as the industries guard the statistics and in many cases they are kept confidential. Recent publications have outlined information regarding resin sales in U.S. and Canada. The information is much more detailed for the U.S. and so both sources of data will be used.

U.S. Resin Sales 1988

HDPE	Trash bags	102 million pounds
LDPE	Grocery bags	84 million pounds
	Self service bags	92 million pounds
	Agricultural	172 million pounds
	Diaper backing	210 million pounds
	Trash bags	1250 million pounds

Canadian Resin Statistics 1988

Domestic Demand	HDPE - Total	602 million pounds
	Film	42 million pounds
	LDPE - Total	1086 million pounds
	Film	795 million pounds 41

As noted, the report details more information for the U.S. markets and tends to be much broader for the Canadian market. A 10% value of the U.S. market will give a conservative look at the Canadian potentials.

Other Markets

Fillers for Fertilizer

Filler is an inexpensive component used to fill up fertilizer bags. It is used primarily in retail lawn and garden fertilizers to make them come out at a certain analysis to ensure that the average person does not burn their lawn. On average, fillers comprise 20% of the fertilizer used. Fillers are rarely used in agricultural or farming fertilizer as the end user is more knowledgable.

The biggest market for fillers is in Ontario, followed by the Maritimes and Quebec. It appears to be an Eastern phenomena and is rarely used in Western Canada.

Fillers - Ontario	55,000 tonnes	
- Quebec	16,528 tonnes	
- Maritimes	19,722 tonnes	42

Fillers commonly use corn cob husks which range in price from $100 - 200 per tonne.

Calcidic or dolimitic limestone, which is the most common filler, is about $25 per tonne.43

Fillers for Paints

The amount of filler required in paint depends on the glossiness of the paint. Flat paint requires the highest concentration of an extender while the glossy paint requires lower concentrations of an extender (filler).44

Two commonly used fillers are calcium carbonate at 18 cents per pound and clay at 20 cents per pound.45

The following figures represent dollars and volume sales of paints sold to retailers for household and commercial use. These figures do not include automotive or industrial applications. They are representative of 80% of the total paint manufacturers who participated.

Canada	127,204,108 litres	$404,205,895	
Ontario	36,695,758 litres	$106,169,216	46

SUMMARY

The "biodegradable" issue has become a topic of great controversy. We have opinions and input from industry, government, public sectors, and environmental groups. There are no concrete answers, but a great deal of concern has been raised regarding the benefit of biodegradables. There are a number of groups actively and aggressively campaigning against biodegradables, two being Pollution Probe and the Recycling Council of Ontario.

The Plastic Industry is presently looking at large scale recycling as a means of dealing with the waste disposal problems. It is generally felt that biodegradables will interfere with recycling programs as they will contaminate and weaken untreated plastics. The Ministry of Environment jointly with the Society of the Plastics Industry of Canada (SPI) will undertake a study on the Impact of Biodegradables on Recycling and the Environment. Results are expected to begin emerging within six months and the final report within one year.

Domtar has announced a major plastic recycling initiative with Dow Chemical to establish a major facility to recycle mixed plastics in either Ontario or the N.E. United States. The company has specifically indicated its concern over degradable plastics in the consumer waste stream. Recycling problems may adversely affect the end-markets for the recycled plastics Domtar will be producing i.e., industrial building products and industrial packaging. As a result, Domtar will refuse loads found to contain any degradable plastic.[47]

Many groups against biodegradables are hoping to see full scale bans and, at the very least, limited use of biodegradables. According to the Executive Director at the Recycling Council of Ontario, environmental groups and individuals who were pro biodegradables are gradually changing their attitudes. The biodegradable situation is changing daily which makes obtaining up-to-date information an ongoing problem. For example, the Metro

Works Department sent out a recommendation for biodegradable garbage bags, but the latest information states that they will no longer endorse the bags.

At the writing of this report there are no standards for testing biodegradables. Any company introducing a new biodegradable at this time would probably be met with a mixture of interest and skepticism. A great deal of responsibility would be left to the developer to provide extensive test results including the following information:

- Initiation and rate of degradation in a landfill situation;
- Results of by-product after degradation and proof that there is no toxic residue;
- Impact on recyclable plastics.

There is also feedback that photodegradable/biodegradable products would lead to further litter problems as the public may perceive these treated products as disappearing on their own. Cost is also an issue. With the present use of added resins, the weight or gauge of the plastic must be increased as the additive weakens the plastic. It is generally felt that a 10-15% increase would be accepted.

Regardless of all the controversy, there is still a great deal of interest, research and time being spent on biodegradables. There appears to be specific market niches emerging where a biodegradable plastic could prove to be beneficial and, at the present, are not receiving opposition. One area is agricultural mulch and the other, time release fertilizers.

Degradable plastics may have a role to play so long as they can be proven not to interfere with recycling programs nor to pose any harm to the environment.

There is a need for more research as the existing biodegradables available are not meeting expectations of what they are supposed to do.

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